ABSTRACT

On closing the door, that is conventionally hinged to the vehicle body, keys of interengagable assemblies smoothly engage with mating receptacles located on both pillars, the vehicle roof and side rail. The smooth interengagement is ensured by the adjusting mechanisms of the keys, located on the front, rear, upper and lower reinforced portion of the door, to reduce large clearances between them and their receptacles to minimum tolerances. In an accident the door tightly mates with the door-aperture of vehicle body whereby energy is distributed to the integrated vehicle body.

In the second feature of invention, the interengagable assemblies of a vehicular couple, consisting of the portion of the door and a member of the vehicle body, are arranged in at least two operating planes.

In the third feature, the deformation of the series-connected doors and their common pillar is constrained in an accident owing to an extension member, rigidly attached to the common pillar, accommodating the keys, which tightly mate with the receptacles located on the rear portion of the front door and the front portion of the rear door.

In the fourth and fifth feature, the interengagable assemblies of the vehicular couple are arranged in multi-operating planes thus cutting costs associated with less adjusting work to reduce large clearances to small tolerances.

This inventive technology is applicable for other door-types such as tailgate-, sliding side-, cargo-, liftgate door, trunk cover and hood to define a substantially stiffer vehicle body whereby stress is enormously decreased in an accident.

1. An increased stiffness of vehicle structure comprising

a main vehicle body **(20)** having at least one door aperture **(20.1, 20.1B, 20.1T, 20.1h, 20.1x)** therein;

a mating vehicle door **(8, 8B, 8T, 8h, 8x)**, generally representing a tailgate- **(8T)**, sliding side-, cargo-, liftgate door, trunk cover **(8x)**, hood **(8h)** or vehicle door **(8, 8B)**, whose door frame, reinforced by at least two impact beams **(1, 7, 1B, 7B)**, spanning the door aperture, elements and at least one window-guide channel **(6, 6B, 6.1, 6.2, 6.1B, 6.2B, 6.1a, 6.2a, 6.1aB, 6.2aB)** to guide and receive a window pane, is hingedly secured to that vehicle body **(20)** for pivotal movement between an open and a closed position;

interengaging assemblies, each of which includes a key arranged to one of the reinforcing members of that door frame, facing a vehicular member of that vehicle body, and a mating receptacle located thereon; and

adjusting mechanisms to reduce the clearances between the adjustable keys and the mating receptacles to minimum tolerances, when the vehicle door is closed, to ensure the engagement of the interengaging assemblies and the connection of the vehicular couples consisting of

vehicle door & vehicle roof **(17)**,

vehicle door & side rail **(18)**,

vehicle door & pillar and

vehicle door & flange **(21, 21T, 21h, 21x)** of the vehicle body **(20)**

thus distributing impact energy to all vehicular members, lowering stress thereof and preventing passenger from being hurled out of the motor vehicle in the event of an accident.

2. An increased stiffness of vehicle structure comprising

a main vehicle body **(20)** having at least three door apertures **(20.1, 20.1B, 20.1T, 20.1h, 20.1x)**, two of which are series-connected, therein;

three mating vehicle doors **(8, 8B, 8T, 8h, 8x)**, each of which generally representing a tailgate- **(8T)**, sliding side-, cargo-, liftgate door, trunk cover **(8x)**, hood **(8h)** or vehicle door **(8, 8B)**, whose door frame, reinforced by at least two impact beams **(1, 7, 1B, 7B)**, spanning the door aperture, elements

and at least one window-guide channel **(6, 6B, 6.1, 6.2, 6.1B, 6.2B, 6.1a, 6.2a, 6.1aB, 6.2aB)** to guide and receive a window pane, is hingedly secured to that vehicle body **(20)** for pivotal movement between an open and a closed position;

interengaging assemblies, each of which includes a key arranged to one of the reinforcing members of that door frame, facing a vehicular member of that vehicle body, and a mating receptacle located thereon;

at least one extension member **(17.3, 18.3, 23)**, mounted to a common pillar of the series-connected vehicle doors, to receive at least two keys mating to the receptacles, located on the respective reinforcing members of those doors, when closed, for exploiting the constrained deformation thereof to prevent them from popping open in the event of an accident; and

adjusting mechanisms to reduce the clearances between the adjustable keys and the mating receptacles to minimum tolerances, when the vehicle doors are closed, to ensure the engagement of the interengaging assemblies and the connection of the vehicular couples consisting of

vehicle door & vehicle roof **(17)**,

vehicle door & side rail **(18)**,

vehicle door & pillar,

series-connected vehicle doors & common pillar and

vehicle door & flange **(21, 21T, 21h, 21x)** of the vehicle body **(20)**

thus distributing impact energy to all vehicular members, lowering stress thereof and preventing passengers from being hurled out of the motor vehicle in the event of an accident.

3. An increased stiffness of vehicle structure comprising

a main vehicle body **(20)** having at least one door aperture **(20.1, 20.1B, 20.1T, 20.1h, 20.1x)** therein;

a mating vehicle door **(8, 8B, 8T, 8h, 8x)**, generally representing a tailgate- **(8T)**, sliding side-, cargo-, liftgate door, trunk cover **(8x)**, hood **(8h)** or vehicle door **(8, 8B)**, whose door frame, reinforced by at least two impact beams **(1, 7, 1B, 7B)**, spanning the door aperture, elements and at least one window-guide channel **(6, 6B, 6.1, 6.2, 6.1B, 6.2B, 6.1a, 6.2a, 6.1aB, 6.2aB)** to guide and receive a window

pane, is hingedly secured to that vehicle body **(20)** for pivotal movement between an open and a closed position;

interengaging assemblies, each of which includes a key arranged to one of the reinforcing members of that door frame, facing a vehicular member of that vehicle body, and a mating receptacle located thereon; and

adjusting mechanisms to reduce the clearances between the adjustable keys and the mating receptacles to permissible tolerances, when the vehicle door is closed, to ensure the engagement of the interengaging assemblies and the connection of the vehicular couples, at least one thereof has a plurality of interengaging assemblies operating at least at two planes, consisting of

vehicle door & vehicle roof **(17)**,

vehicle door & side rail **(18)**,

vehicle door & pillar and

vehicle door & flange **(21, 21T, 21h, 21x)** of the vehicle body **(20)**

thus distributing impact energy to all vehicular members, lowering stress thereof and preventing passengers from being hurled out of the motor vehicle in the event of an accident.

4. An increased stiffness of vehicle structure comprising

a main vehicle body **(20)** having at least one door aperture **(20.1, 20.1B, 20.1T, 20.1h, 20.1x)** therein;

a mating vehicle door **(8, 8B, 8T, 8h, 8x)**, generally representing a tailgate- **(8T)**, sliding side-, cargo-, liftgate door, trunk cover **(8x)**, hood **(8h)** or vehicle door **(8, 8B)**, whose door frame, reinforced by at least two impact beams **(1, 7, 1B, 7B)**, spanning the door aperture, elements and at least one window-guide channel **(6, 6B, 6.1, 6.2, 6.1B, 6.2B, 6.1a, 6.2a, 6.1aB, 6.2aB)** to guide and receive a window pane, is hingedly secured to that vehicle body **(20)** for pivotal movement between an open and a closed position;

interengaging assemblies, each of which includes a key arranged to one of the reinforcing members of that door frame, facing a vehicular member of that vehicle body, and a mating receptacle located thereon, when the vehicle door is closed, to ensure the engagement of the interengaging assemblies and the

connection of the vehicular couples, at least one thereof has a plurality of interengaging assemblies operating at least at two planes. consisting of

vehicle door & vehicle roof **(17)**,

vehicle door & side rail **(18)**,

vehicle door & pillar and

vehicle door & flange **(21, 21T, 21h, 21x)** of the vehicle body **(20)**

thus distributing impact energy to all vehicular members, lowering stress thereof and preventing passengers from being hurled out of the motor vehicle in the event of an accident.

5. An increased stiffness of vehicle structure comprising

a main vehicle body **(20)** having at least three door apertures **(20.1, 20.1B, 20.1T, 20.1h, 20.1x)**, two of which are series-connected. therein;

three mating vehicle doors **(8, 8B, 8T, 8h, 8x)**, each of which generally representing a tailgate- **(8T)**, sliding side-, cargo-, liftgate door, trunk cover **(8x)**, hood **(8h)** or vehicle door **(8, 8B)**, whose door frame, reinforced by at least two impact beams **(1, 7, 1B, 7B)**, spanning the door aperture, elements and at least one window-guide channel **(6, 6B, 6.1, 6.2, 6.1B, 6.2B, 6.1a, 6.2a, 6.1aB, 6.2aB)** to guide and receive a window pane, is hingedly secured to that vehicle body **(20)** for pivotal movement between an open and a closed position;

at least one extension member **(17.3, 18.3, 23)**, mounted to a common pillar of the series-connected vehicle doors, to receive at least two keys mating to the receptacles, located on the respective reinforcing members of those doors, when closed, for exploiting the constrained deformation thereof to prevent them from popping open in the event of an accident; and

interengaging assemblies, each of which includes a key arranged to one of the reinforcing members of that door frame, facing a vehicular member of that vehicle body, and a mating receptacle located thereon, when the vehicle door is closed, to ensure the engagement of the interengaging assemblies and the connection of the vehicular couples, at least one thereof has a plurality of interengaging assemblies operating at least at two planes. consisting of

vehicle door & vehicle roof **(17)**,

vehicle door & side rail **(18)**,

vehicle door & pillar,

series-connected vehicle doors & common pillar and

vehicle door & flange **(21, 21T, 21h, 21x)** of the vehicle body **(20)**

thus distributing impact energy to all vehicular members, lowering stress thereof and preventing passengers from being hurled out of the motor vehicle in the event of an accident.

6. An increased stiffness of vehicle structure according to claim **1**, wherein the interengaging assembly of vehicle door & vehicle roof **(17)** consists of

at least two hooks **(15.6)** mounted to the window-guide channels **(6.1a, 6.2a, 6.3, 6.4** or **6.1aB, 6.2aB, 6.3B, 6.4B)**; and

a mating rod **(17.1d)** arranged along that vehicle roof and mounted to two transverse girders **(17.2e, 17.2f, 17.2g)** connecting the pillars of both vehicle sides to each other.

7. An increased stiffness of vehicle structure according to claim **1**, wherein the interengaging assembly of vehicle door & side rail **(18)** consists of

at least two hooks **(15.6)** mounted to the window-guide channels **(6.1a, 6.2a, 6.3, 6.4** or **6.1aB, 6.2aB, 6.3B, 6.4B)**; and

a mating rod **(17.1d)** arranged along that side rail and mounted to two transverse girders **(17.2e, 17.2f, 17.2g)** connecting the pillars of both vehicle sides to each other.

8. An increased stiffness of vehicle structure according to claim **1**, wherein the interengaging assemblies of series-connected vehicle doors & vehicle roof **(17)** and series-connected vehicle doors & side rail **(18)** consist of

at least eight hooks **(15.6)** mounted to the corresponding window-guide channels; and

two mating rods **(17.1d)** arranged along that vehicle roof and side rail and mounted to three transverse girders **(17.2e, 17.2f, 17.2g)**, connecting all pillars of both vehicle sides to each other.

9. An increased stiffness of vehicle structure according to claim 1, wherein the adjustable interengaging assembly of vehicle door & pillar, whereto the door hinges are fastened, consists of

a key **(15.1)** bolted to the intersection region of the pillar and roof, which is reinforced by a plate **(17.1c)** and transverse girder **(17.2d)**, connecting the pillars of both vehicle sides to each other; and

a mating hole arranged to the window-guide channel **(6.1a, 6.2a, 6.1aB, 6.2aB)**.

10. An increased stiffness of vehicle structure according to claim 1, wherein the adjustable interengaging assemblies of vehicle door & vehicle roof consist of

a key **(15.2a)**, bolted to an element **(6.11)** rigidly attached to the respective window-guide channel **(6.1a, 6.2a, 6.3, 6.4, 6.1aB, 6.2aB, 6.3B, 6.4B)**, and a plurality of keys **(15.2)**, bolted to the respective window-guide channels; and

mating holes arranged to the vehicle roof **(17)**, reinforced by a plate **(17.1, 17.1a)** and transverse plate **(17.2a)** connecting the pillars of both vehicle sides to each other.

11. An increased stiffness of vehicle structure according to claim 1, wherein the interengaging assemblies of vehicle door & side rail consist of

a plurality of keys **(15.4, 15.4a)** mounted to the respective window-guide channels **(6.1a, 6.2a, 6.3, 6.4, 6.1aB, 6.2aB, 6.3B, 6.4B)**; and

mating holes arranged to the side rail **(18)** reinforced by an element **(18.1, 18.1a)**.

12. An increased stiffness of vehicle structure according to claim 1, wherein the interengaging assemblies of vehicle door & vehicle roof and vehicle door & side rail consist of

a plurality of keys **(15.2, 15.4, 15.4a)** mounted to the respective window-guide channels **(6.1a, 6.2a, 6.3, 6.4, 6.1aB, 6.2aB, 6.3B, 6.4B)**; and

mating holes arranged to the vehicle roof **(17)**, reinforced by the plate **(17.1a)**, and to the side rail **(18)**, reinforced by an element **(18.1, 18.1a)**.

13. An increased stiffness of vehicle structure according to claim **1**, wherein the adjustable interengaging assemblies of vehicle doors & flange **(21)** of the vehicle body **(20)** consist of

a plurality of keys **(30, 32, 35)** bolted to the reinforced flange **(21)** of the vehicle body **(20)**; and

mating holes arranged to the housings **(6.5, 6.5B)** rigidly attached to the window-guide channels **(6, 6B)**, retaining members **(6.6b, 6.7b, 6.8)** and impact beams **(7, 7B)**, respectively.

14. An increased stiffness of vehicle structure according to claim **1**, wherein the key **(15.6)**, adjustable from outside the vehicle, comprises a bolt **(15.21)**, a number of spacers **(15.22)**, washer **(15.24)**, nut **(15.25)** and a hook **(15.6)** with interior diameter (d_1) and gap (s_1).

15. An increased stiffness of vehicle structure according to claim **1**, wherein the key, adjustable from outside the vehicle, comprises a bolt **(15.14)**, large washer **(15.13)** with outer diameter (D), a number of spacers **(15.12)** and a sleeve **(15.11)**, both have a total length (l).

16. An increased stiffness of vehicle structure according to claim **15**, wherein the sleeve **(15.11)** of the key with exterior diameter (d) is governed by the equation ($D \geq d \geq d_R$), where (D) is the exterior diameter of washer **(15.13)** and (d_R) is the diameter of spacer **(15.12)** and sleeve.

17. An increased stiffness of vehicle structure according to claim **15**, wherein the front region of washer **(15.13)** has radial teeth.

18. An increased stiffness of vehicle structure according to claim **15**, wherein the washer is an integral part of the bolt.

19. An increased stiffness of vehicle structure according to claim **1**, wherein both ends of the U-shaped window-guide channel **(6, 6B)**, facing the lower vehicular member of the vehicle body **(20)**, and an upper portion of that window-guide channel, facing the upper vehicular member of the vehicle body **(20)**, accommodate the members of interengaging assemblies.

20. An increased stiffness of vehicle structure according to claim **19**, wherein both ends of the respective stiff U-shaped window-guide channel **(6, 6B)** are connected to each other by a window-guide member **(6.4, 6.4B)**.

21. An increased stiffness of vehicle structure according to claim **1**, wherein the window-guide channels **(6.1, 6.2, 6.1B, 6.2B)** are rigidly attached to the respective stiff window-guide members **(6.1a, 6.2a, 6.1aB, 6.2aB)**.

22. An increased stiffness of vehicle structure according to claim **1**, wherein the adjustable interengaging assemblies of vehicle door & pillar, whereto the vehicle door hinges are fastened, consist of

a plurality of keys **(31, 36)** bolted to a retaining member **(6.6a, 6.8)**, rigidly attached to the window-guide channel **(6, 6B)**, and impact beams **(1, 1B, 7, 7B)**; and

mating holes arranged to the pillar reinforced by an extension member **(23)**.

23. An increased stiffness of vehicle structure according to claim **2**, wherein the adjustable interengaging assemblies of series-connected vehicle doors & common pillar are defined by

at least one pair of keys **(15.3, 15.3a)** bolted to both legs of the U-shaped extension member **(17.3)**, mounted to the common pillar, reinforced by a plate **(17.1b)**, arranged along the vehicle roof **(17)** and attached rigidly to a transverse girder **(17.2c)**, connecting the common pillars of both vehicle sides to each other; and

mating holes arranged to both window-guide channels of series-connected vehicle doors adjacent to that common pillar.

24. An increased stiffness of vehicle structure according to claim **2**, wherein the adjustable interengaging assemblies of series-connected vehicle doors & common pillar are defined by

at least one pair of keys **(15.5, 15.5a)** bolted to both legs of the U-shaped extension member **(18.3)** mounted to the common pillar, reinforced by an element **(18.1b)**, arranged along the side rail **(18)** and

attached rigidly to a transverse girder **(18.2)**, connecting the common pillars of both vehicle sides to each other; and

mating holes arranged to both window-guide channels of series-connected vehicle doors adjacent to that common pillar.

25. An increased stiffness of vehicle structure according to claim **24**, wherein a belt case **(26)** is accommodated in the U-shaped extension member **(18.3)**.

26. An increased stiffness of vehicle structure according to claim **3**, wherein the adjustable interengaging assemblies of vehicle door **(8)** & pillar, operating in two planes, are defined by

a plurality of keys **(33)** bolted to the window-guide channel and a plurality of keys **(34)**, bolted to a retaining members **(6.7a)**, rigidly attached to the window-guide channel **(6)** and impact beams **(1, 7)**; and

the mating receptacles arranged to the reinforced pillar.

27. An increased stiffness of vehicle structure according to claim **3**, wherein the adjustable interengaging assemblies of vehicle door **(8, 8B)** & pillar, operating in three planes, are defined by

a plurality of keys **(15.1)** rigidly arranged to the reinforced pillar, whereto the door frame is hingedly secured, and a plurality of keys **(30, 31, 35, 36)**, rigidly arranged to the reinforced flange **(21)** of the vehicle body **(20)**; and

the mating receptacles arranged to retaining members **(6.6a, 6.8)**, housings **(6.5, 6.5B)** and the window-guide channel **(6.1a, 6.2a)**, respectively.

28. An increased stiffness of vehicle structure according to claim **4**, wherein the interengaging assemblies of vehicle door **(8, 8B)** & vehicle roof **(17)**, operating in four planes, are defined by

a plurality of keys **(15.2, 15.2a)** rigidly arranged to the respective window-guide channels **(6.1a, 6.2a, 6.3, 6.4, 6.1aB, 6.2aB, 6.3B, 6.4B)** and at least two keys **(30, 32, 35, 37)**, rigidly arranged to the reinforced flange **(21)** of the vehicle body **(20)**; and

the mating receptacles arranged to the reinforced vehicle roof **(17)** and that window-guide channels, respectively.

29. An increased stiffness of vehicle structure according to claim **4**, wherein the interengaging assemblies of connecting vehicular couples, operating in many planes, are defined by

a plurality of keys **(15.1 to 15.7, 30, 32, 35, 37)** rigidly arranged to the reinforced pillar, reinforced vehicle roof, reinforced side rail and reinforced flange of vehicle body, respectively; and

the mating receptacles arranged to the reinforcing members of vehicle doors, respectively.

30. An increased stiffness of vehicle structure according to claim **5**, wherein a member **(6.5C)**, whose contour is adapted to the door-contour, is rigidly attached to the window-guide channel **(6B)** and impact beams **(1B, 7B)**.

31. An increased stiffness of vehicle structure according to claim **30**, wherein the adjustable interengaging assemblies consist of

a plurality of keys **(37)** bolted to the rear flange **(21)** of the vehicle body **(20)** reinforced by an element **(21.4B, 21.6B, 21.5B)**; and

mating holes arranged to the door-contour-shaped member **(6.5C)**.

32. An increased stiffness of vehicle structure according to claim **31**, wherein the adjustable interengaging assemblies of vehicle door **(8, 8B)** & side rail **(18)**, operating in three planes, are defined by

a plurality of keys **(15.4a)** rigidly arranged to the side rail **(18)** and at least two keys **(30, 32, 35, 37)**, rigidly arranged to the reinforced flange **(21)** of the vehicle body **(20)**; and

the mating receptacles arranged to housings **(6.5, 6.5B)**, the window-guide channels **(6.1a, 6.2a, 6.3, 6.4, 6.1aB, 6.2aB, 6.3B, 6.4B)** and door-contour-shaped member **(6.5C)**, respectively.

33. An increased stiffness of vehicle structure according to claim **5**, wherein the interengaging assemblies of series-connected vehicle doors & common pillar, operating in many planes, are defined by

a plurality of keys **(15.3, 15.3a, 15.5, 15.5a)** rigidly arranged to the extension members **(17.3, 18.3, 23)** of the common pillar and a plurality of keys **(33, 34, 36)**, rigidly arranged to the reinforcing members of series-connected vehicle doors, respectively; and

the mating receptacles arranged to the reinforcing members of series-connected vehicle doors and the reinforced common pillar, respectively.

34. An increased stiffness of vehicle structure, characterised by use of metal, compound material, glass fibre reinforced material or non-metal material for material of ~~the~~ a key, receptacle, window-guide channel, transverse girder, rod, plate and extension member.